Evaluation and Simulation of the Response Function in the TWIST Experiment

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for the TWIST Collaboration

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The TWIST Collaboration

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University of Alberta*

University of British Columbia

University of Montréal

University of Regina

University of Victoria

United States

Texas A&M University

Valparaiso University

Russia

RRC "Kurchatov Institute"

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http://twist.triumf.ca

Outline

- Introduction to TWIST
- Overview of MC validation method
- Sample validation results
- Conclusions

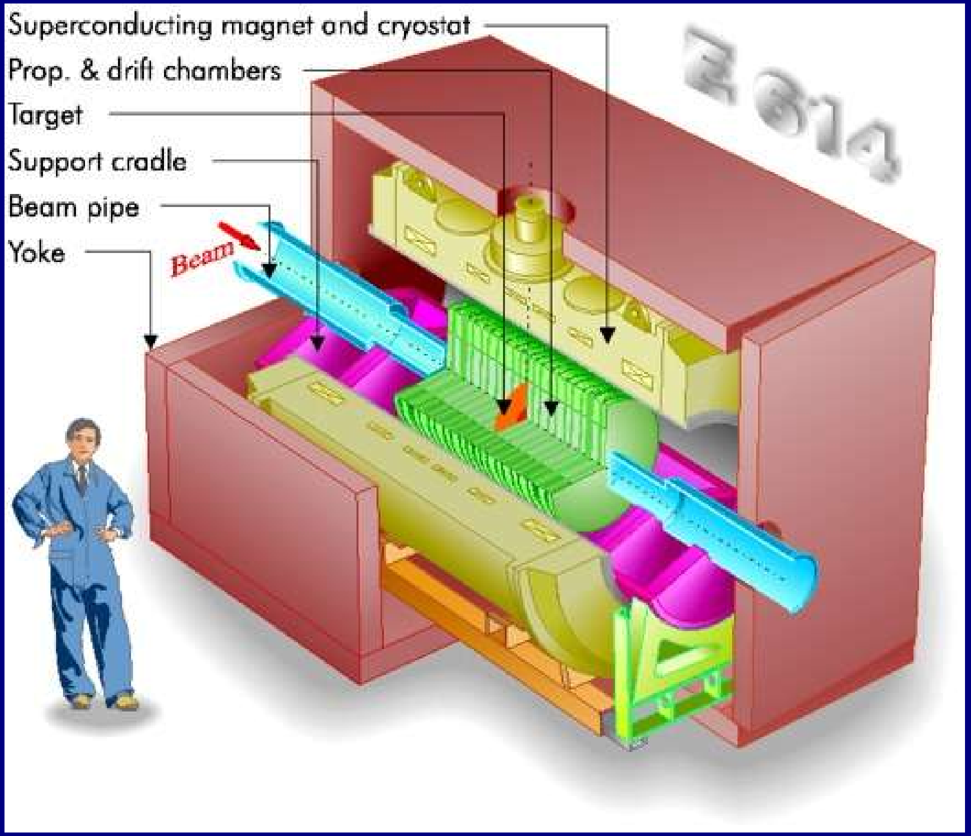
The TWIST Experiment

TRIUMF Weak Interaction Symmetry Test

- Measure (p, cosθ) spectrum of μ^+ decay

$$\mu^+ \to e^+ \nu_e \bar{\nu}_\mu$$

- High-precision test of the weak interaction



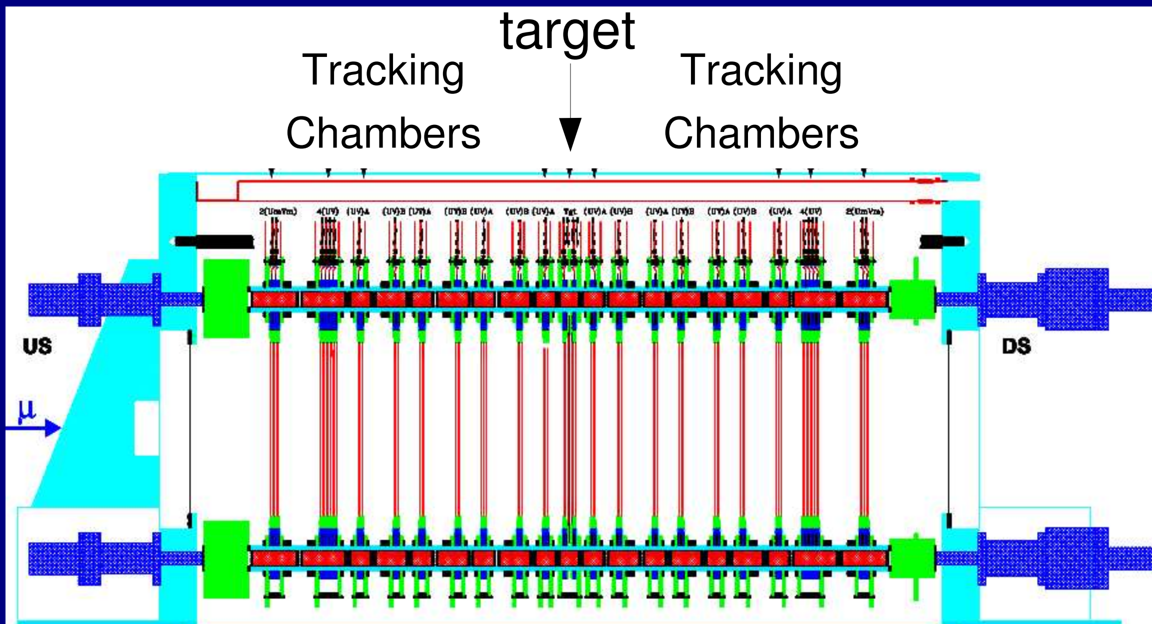
Phys. Rev. Lett. ***94****, 101805 (2005)*

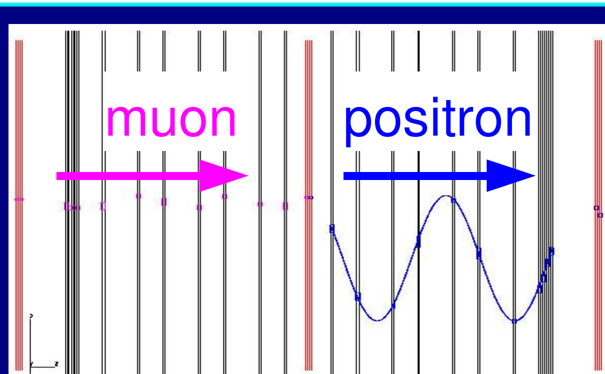
Phys. Rev. D ***71****, 071101(R) (2005)*

See also hep-ex/0409066 (NIM, in press)

Analysis made possible by the Westgrid computing facility.

The TWIST Detector

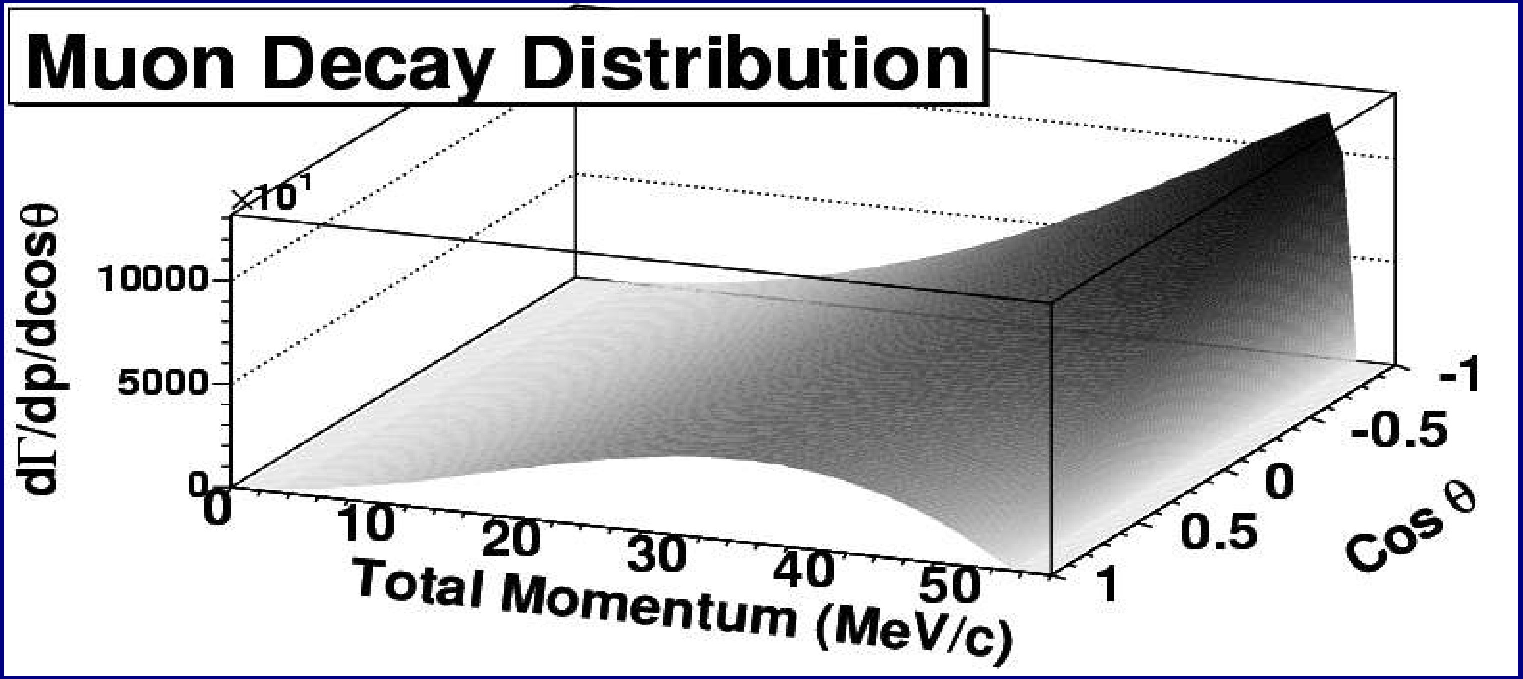




The Michel Spectrum

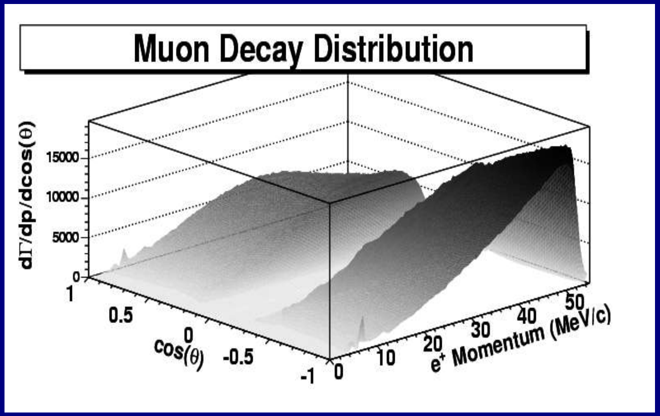
A general description of muon decay spectrum

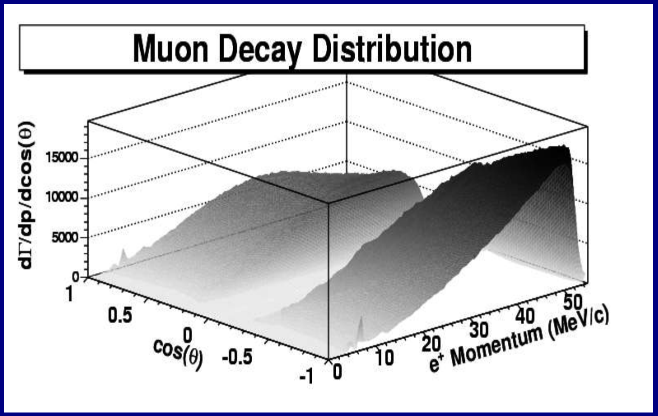
$$N(p,\cos\theta) \propto F_{IS}(p;\rho,\eta) + P_{\mu}\cos\theta\, F_{AS}(p;\xi,\delta)$$



Extracting Michel Parameters

Measured VS Simulated





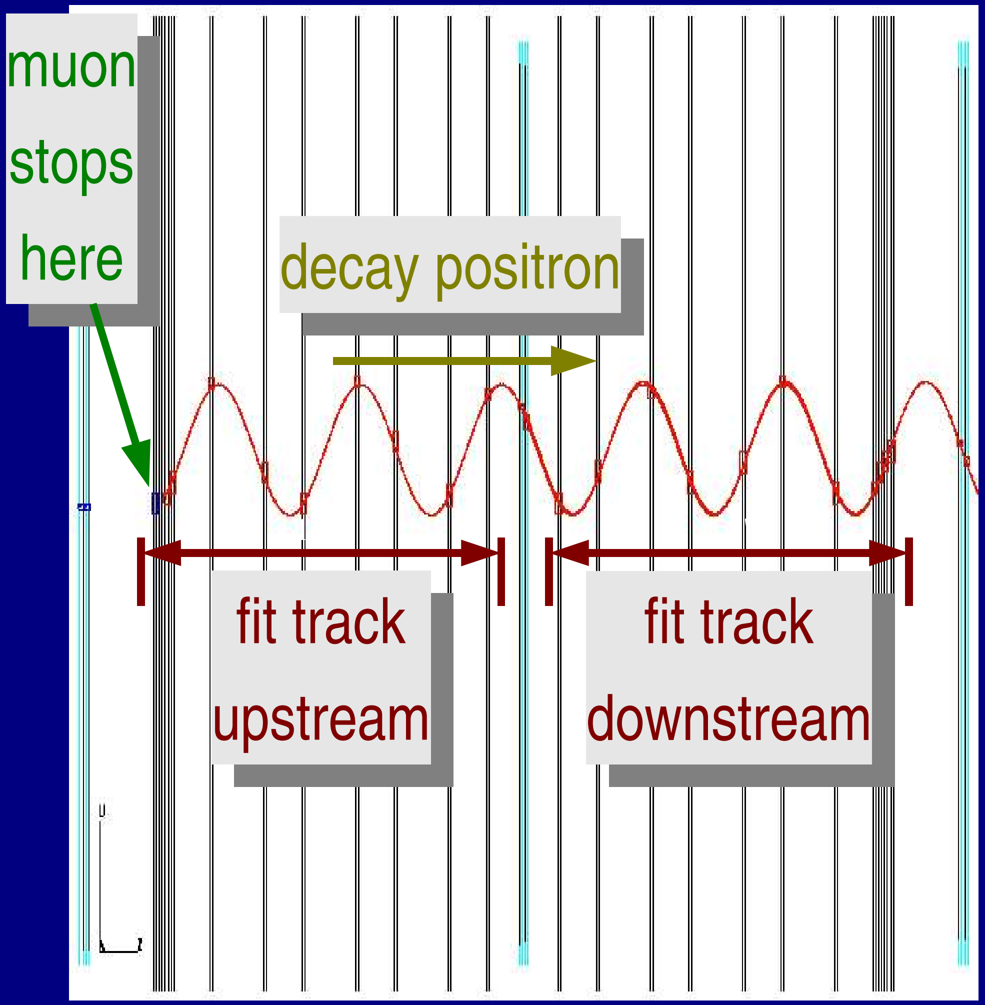
$$\Delta\rho, \Delta\eta, \Delta\delta, \Delta\xi$$

$$\Delta\rho + \rho_{MC} = \rho_{data}$$ etc.

Simulation Software is GEANT3.

Verify MC with Specialized Data

- Stop muons at one end of detector.
- Fit the same track twice: measure of response function in energy and angle.
- Results independent of Michel parameters.



Focus of today's talk: energy response function.

Sensitivity to MC Errors

	(First Physics)→(Final Goals) (~10^{-3})→(few x 10^{-4})			Final MC Tolerances
	ρ	δ	ξ	
Hard Interactions	0.45→0.15	0.53→0.18	0.60→0.20	~7e-4
Energy Smearing	0.18→0.05	0.15→0.05	0.07→0.05	~25 keV
Energy Calibration	0.15→0.05	0.22→0.07	0.27→0.09	few keV

(units of 1e-3)

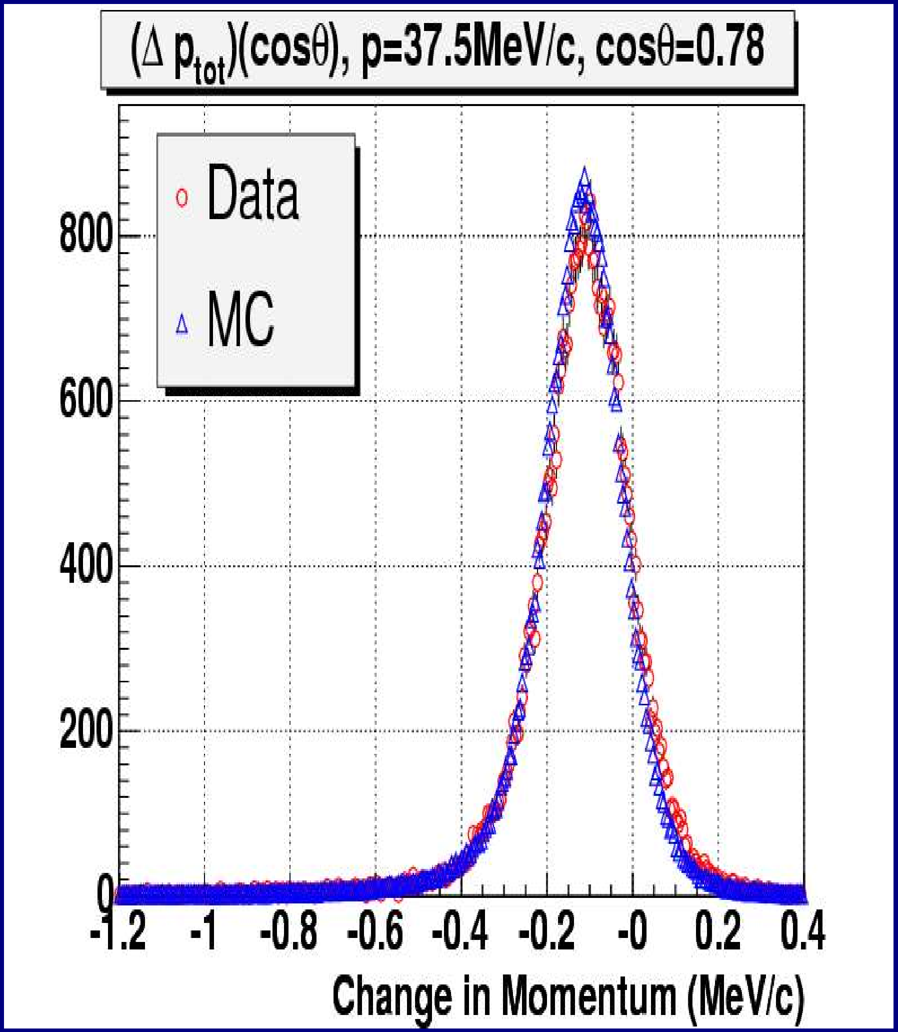
- Inaccuracies in Monte Carlo simulation can result in systematic errors in reconstructed Michel parameters.

Energy Loss Distribution

- Compare energy loss in bins of $(p, \cos\theta)$. Example:

	Mean (keV)
Data	-121.2±0.7
MC	-129.6±0.7

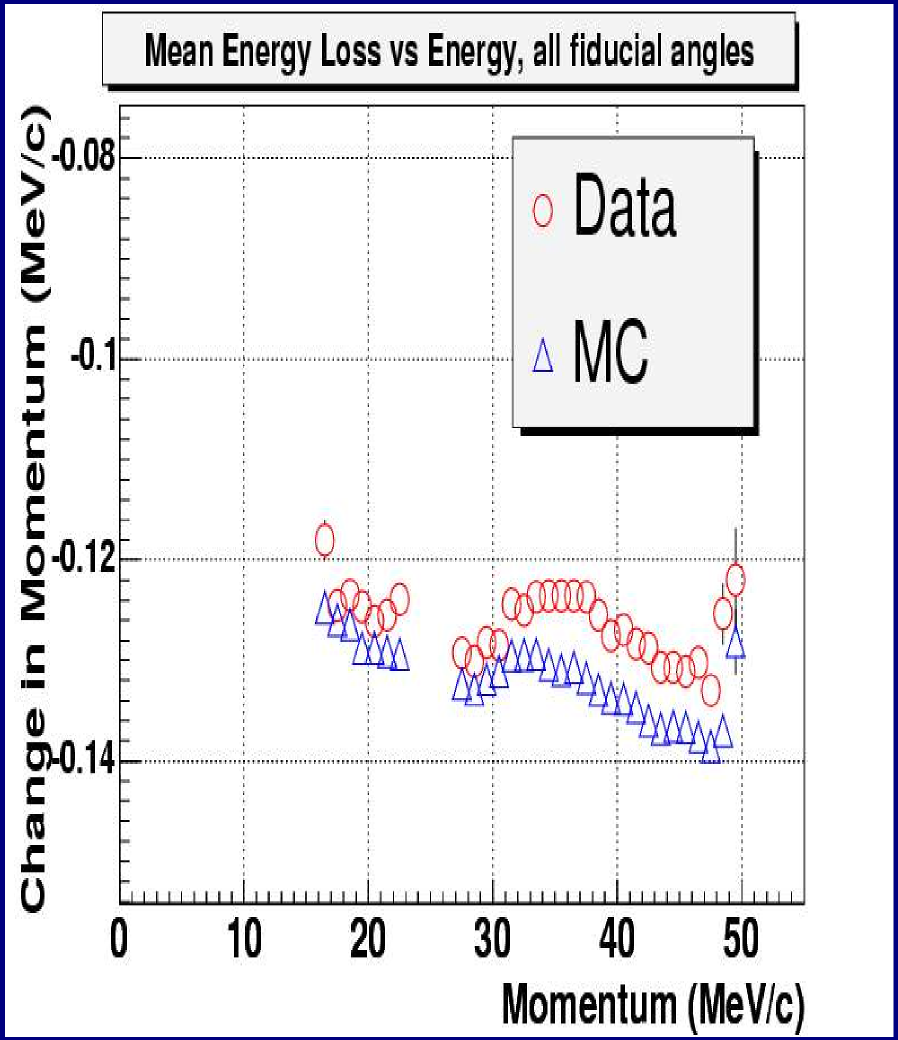
	RMS (keV)
Data	138.6±0.5
MC	133.0±0.5



Energy Loss vs Energy

- Compare energy loss vs total energy. Example:

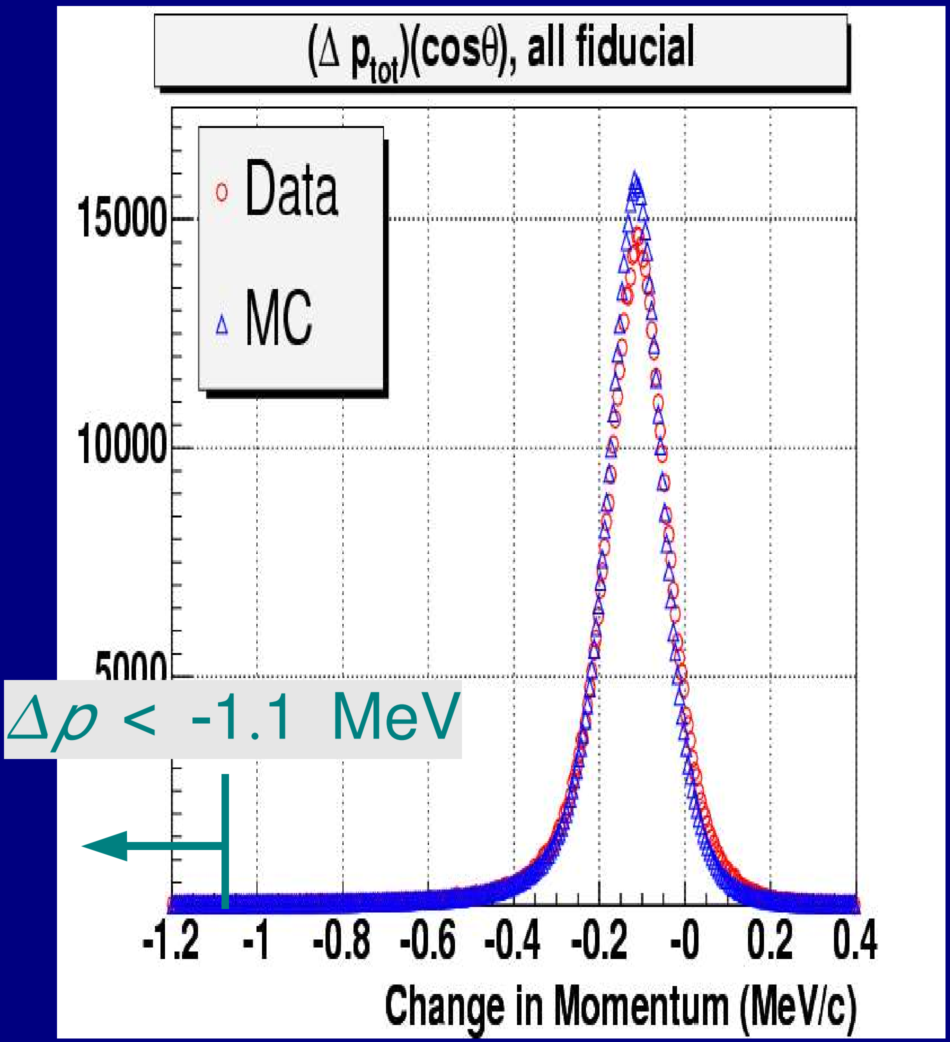
	Mean (keV)
Data	-126.3±0.2
MC	-131.7±0.1



Rate of "Hard" Energy Loss

- Compare rate of events with energy loss > 1.1 MeV. Example:

Rate of "Hard" Δp	
Data	(137.9±8)e-4
MC	(138.4±3)e-4



Conclusion

- Method of testing GEANT3 simulation with high precision.
  - One of the strongest validations of GEANT3 at these energy levels (20 - 50 MeV/c positrons).
- Allows tuning of simulation to meet TWIST goals.
- Very little tuning will be required to meet TWIST's final requirements!
- Work in progress...

Continuing Work

- Study scattering (similar methods).
- Improve analysis.
- Check effects of DC foil thickness.
- Understand details of any remaining discrepancies.

Acceptance of US Stops Study

- Standard fiducial
- Beam positrons
- Target region